REMARKS

Claims 1-26, 50-57 and 66-84 were pending for the final Office Action dated August 13, 2002. Each of the claims stands rejected under various grounds. The Office Action and the cited references have been carefully considered. In light of the amendments presented above and the following remarks, reconsideration and allowance of the subject application are hereby requested.

Claims 1, 5-10, 11, 14, 16, 17-19, 21-26, 50-54, 66, 69-72, 74-78 and 81-84 stand rejected under 35 U.S.C. §102(b) as being anticipated by European Patent Application No. 0 841 406 A1 to Adachi et al.

European Patent Application No. 0 841 406 A1 to Adachi et al. is directed to a method of shaping semisolid metals which teaches two specific methods for generating crystal nuclei (e.g., crystallizing the liquid alloy): 1.) via the use of an agitation source such as a vibrating jig, and 2.) via the use of a grain refiners such as Ti or B. (See e.g., page 6, lines 37-43, page 6, lines 53-56, page 10, lines 1-3). Additionally, referring to Table 3 on page 16, the "Invention Run" Nos. 1-12 each utilize a certain % of a grain refiner to generate the crystal nuclei. With regard to the "Comparison Runs", only Runs 19, 20 and 22 failed to utilize a grain refiner. However, as shown in Table 3 on page 17, regardless of whether grain refiners were used, the disclosed method was only capable of producing a semisolid material having primary crystal sizes between 80-200 μm. Notably, the Runs 19, 20 and 22 that did not utilize a grain refiner produced a semisolid material having primary crystals sizes between 160-200 μm. Accordingly, it is clear from the teachings of the '406 application that the use of grain

refiners during the crystallization stage is a critical feature of the disclosed process.

Independent Claim 1

In view of the above-discussed features and characteristics of the '406 application, the Applicant has amended independent claim 1 to recite that the step of crystallizing the metallic melt in the vessel is accomplished by cooling the metallic melt at a controlled rate less than 0.5 degrees Celsius per second without the use of a grain refiner and without mechanical agitation to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix and having an average diameter no greater than about 50 μm. The Applicant notes that the features incorporated into independent claim 1 were present in original dependent claims 2, 22 and 23, which have now been cancelled without prejudice. As a result, the amendments to independent claim 1 are clearly supported by the application as filed.

Amended independent claim 1 is now believed to clearly distinguish over the process disclosed in the '406 application and in any of the art of record, whether considered alone or in combination. As discussed above, the process disclosed in the '406 application requires either the use of grain refiners or some form of mechanical agitation (i.e., a vibrating jig) to crystallize the liquid alloy. Amended independent claim 1 now expressly states that the use of grain refiners or mechanical agitation is not required to produce the desired microstructure associated with the semi-solid material. Moreover, the results obtained by the process disclosed in the '406 application clearly do not fall within the range now being claimed in independent claim 1, which now recites that rounded solid particles have an average diameter

no greater than about 50 μm. Notably, the smallest particle size obtained by the '406 application process is 80 μm, which is 60% larger than that being claimed in independent claim 1.

Although European Patent Application No. 0 745 694 A1 to Adachi et al. was not specifically asserted against independent claim 1, the Applicant has reviewed this reference as well and submits that the independent claim 1 is also patentable over the subject matter disclosed therein. The '694 application is also directed to a method of shaping semisolid metals. Similar to the '406 application discussed above, the '694 application teaches specific methods for crystallizing the liquid alloy: 1.) by pouring the liquid alloy down a cooling jig 20 to agitate and quickly cool the liquid alloy (Figure 3), 2.) via the use of a mechanical agitation source such as a vibrating jig, and 3.) via the addition of a refiners or additives to the liquid alloy. Moreover, as shown in the report Tables presented in the '694 application, without the addition of significant quantities of refiner additives and/or the application of some form of agitation, the process was incapable of producing rounded solid particles having an average diameter no greater than about 50 μm, as recited in amended independent claim 1.

Contrary to the processes disclosed in the '406 and '694 applications, the method being claimed in the subject application does not rely on the addition of refiners or any form of mechanical agitation to produce a semi-solid material having rounded solid particles having an average diameter no greater than about 50 μm. Instead, the results obtained by the subject invention are attributable to two primary factors, including: 1.) strict regulation of the parameters associated with the transfer of the metallic melt into the temperature-controlled vessel, and 2.)

tight control over the cooling rate of the metallic melt at a rate less than 0.50 degrees Celsius per second. The Applicant also submits that the claimed method presents a significant improvement over prior processes requiring stirring, agitation, or the addition of refiners to the liquid alloy to promote crystallization. More specifically, as set forth in the subject specification, "[a]lthough processes that utilize stirring or other forms of agitation have been found to produce adequate results, the cost and complexity of the associated equipment is relatively high, thereby having the effect of increasing capital expenditures and maintenance costs. Further, the number and complexity of the required process steps is also increased, which also has a tendency to correspondingly increase costs. Additionally, while the use of grain refiners has proven to be somewhat successful in modifying the microstructure of a metallic alloy, the costs associated with this semi-solid production method are relatively high due to the initial cost of the grain refiners and the expense associated with recycling." (Page 5, lines 11-19).

For at least the forgoing reasons, the Applicant submits that independent claim 1, as amended, is clearly distinguishable over the '406 and '694 applications and any of the other art of record, whether considered along or in combination. Accordingly, withdrawal of the rejection of independent claim 1 is respectfully requested.

<u>Dependent Claims 5-9, 11-20, 24-26 and 76</u>

In addition to the reasons supporting the patentability of independent base claim 1, further reasons support the patentability of the claims depending therefrom. For example, dependent claim 8, which has been amended to depend directly from independent claim 1, recites that the regulating further includes transferring the metallic melt into the vessel at a selected

vessel temperature, and dependent claim 9 further recites that the selected vessel temperature is between about 606 degrees Celsius and about 610 degrees Celsius. The Applicant submits that these features are neither taught nor suggested by the '406 application nor the '694 application. Specifically, the '406 and '694 applications fail to disclose that the temperature of the vessel 30 is in any way regulated to a provide a selected temperature prior to transferring of liquid metal into the vessel 30. (See e.g., Figures 3 and 13 in the '406 application and Figures 3 and 29 in the '694 application). The Applicant points out that the temperature range of 606 to 610 degrees Celsius referred to in paragraph 2, line 8 of the Office Action (referring to Table 3 in the '406 application) is the temperature of the <u>metal</u> introduced into the vessel, and does not in any way refer to a selected temperature of the <u>vessel</u> prior to introduction of the metal therein. Accordingly, the Applicant submits that dependent claims 8 and 9 are clearly distinguishable over both the '406 and '694 applications.

(Temp of molten metal is the same temp as temp of the vessel

Additionally, dependent claim 14 recites that the regulating further includes transferring a select amount of the metallic melt into the vessel, with dependent claim 15 reciting a specific range for the select amount of metallic melt transferred into the vessel. However, the '406 and '694 applications fail to teach or suggest that regulation of the amount of molten metal transferred into the vessel is of any importance whatsoever. The Applicants also submit that regulation of the amount of metallic melt transferred into the vessel is not a mere matter of design choice. To the contrary, the selected amount of metallic melt that is transferred into the vessel can have a significant impact on properly controlling the cooling rate of the metallic melt. For example, transferring small quantities of metallic melt into the vessel can result in rapid

cooling of the metallic melt, while transferring large quantities of metallic melt into the vessel can result in non-uniform cooling rates that tend to produce a non-homogenous semi-solid microstructure.

Dependent claim 16 recites that the regulating includes controlling a differential between the temperature of the metallic melt during the heating and the temperature of the metallic melt during the transferring, and dependent claim 17 further recites that the regulating includes controlling a drop in temperature of the metallic melt during the transferring of the metallic melt into the vessel. Once again, the Applicant submits that these features are neither taught nor suggested by the '406 and '694 applications. While the '406 and '694 applications appear to disclose a preferred heating temperature range for the molten metal and a preferred temperature range of the molten metal prior to being charged into the vessel, there is no indication or suggestion regarding providing control over the temperature differential between the molten metal during the heating and transferring steps. Likewise, the '406 and '694 applications fail to disclose or suggest providing control over the temperature drop of the molten metal during its transfer into the vessel. The Applicant submits that each of these steps is associated with the "regulating" step recited in independent base claim 1 and has a non-obvious effect on producing a semi-solid material having a predetermined microstructure (e.g., rounded solid particles having a diameter no greater than 50 μm).

Further, dependent claim 24 recites that the temperature-controlled vessel is a shot sleeve of a semi-solid forming press. Dependent claim 25 further recites that the semi-solid material is injected from the shot sleeve (i.e., the temperature-controlled vessel) directly into a die mold.

This embodiment of the claimed invention is illustrated in Figure 9 of the subject application. However, the Applicant submits that these features are neither taught nor suggested by the '406 and '694 applications. More specifically, referring to Figures 3 and 13 in the '406 application, the vessel 30 is clearly separate and distinct from the injection sleeve 50, 180. Similarly, referring to Figures 3, 29, etc. in the '694 application, the vessel 30 is clearly separate and distinct from the injection sleeve 40, 70. Indeed, nowhere in the '406 application or the '694 application is it taught or even suggested that the functions associated with the vessel 30 (e.g., receiving and controlling the cooling rate of the liquid alloy) and the injection sleeve 40, 50, 70, 180 (e.g., injecting the semisolid material into a mold to form a part) are incorporated into the <u>same structure</u> such that the semi-solid material may be injected <u>directly into a die mold</u>.

Instead, with regard to the '406 and '694 applications, the semisolid material must be transferred from the vessel into the injection sleeve, and then from the injection sleeve into the mold. As should be appreciated, this added process step requires additional time, thereby increasing processing time. Additionally, the added step of discharging the semisolid material from the vessel into the injection sleeve increases the likelihood of contamination of the semisolid material, and may also effect the temperature of the semisolid material prior to injection into the mold, which may in turn have a negative effect on material microstructure. Accordingly, it is respectfully submitted that dependent claims 24 and 25 are distinguishable over the subject matter disclosed in the '406 and '694 applications.

Dependent claim 76 recites that the vessel includes a plurality of heat transfer zones, and that the cooling of the metallic melt at the controlled rate comprises independently

controlling the temperature of the metallic melt disposed adjacent each of the heat transfer zones. These features are illustrated, for example, in Figure 9 of the subject application, wherein the vessel 80 is equipped with two independently-controlled heat transfer zones 102a, 102b. As should be appreciated, providing multiple heat transfer zones provide a greater degree of control over the cooling rate of the metallic melt throughout the entire vessel, thereby producing a material with superior characteristics (e.g., small diameter rounded particles) and a more homogenous material microstructure. Notably, the vessels disclosed in the '406 and '694 applications fail to disclose or even suggest independent control of the temperature of the metallic melt via two or more heat transfer zones, as recited in dependent claim 76.

Independent Claim 10

Independent claim 10 recites the steps of heating a metal alloy to form a metallic melt, transferring a portion of the metallic melt into a holding vessel, controllably adjusting the temperature of the metallic melt in the holding vessel to a selected transfer temperature, regulating the transfer of an amount of the metallic melt from the holding vessel into a temperature-controlled forming vessel, and crystallizing the metallic melt in the forming vessel by cooling the metallic melt at a controlled rate to form a semi-solid material.

Referring to Figures 3 and 13 of the '406 application and Figures 3, 29, etc. in the '694 application, even assuming arguendo that the ladle 10 could be considered a holding vessel and that the vessel 30 is a forming vessel, there is no indication or even a suggestion that the temperature of the liquid metal contained within the ladle 10 is "controllably

adjusted" to a selected transfer temperature, as recited in independent claim 10. Instead, the temperature of the molten metal within the ladle 10 is subjected to uncontrolled ambient cooling. In no manner can it fairly be said that the ladle 10 satisfies the requirement of "controllably adjusting" the temperature of the molten metal to a selected transfer temperature prior to transferring the liquid metal to the vessel 30. Additionally, the Applicant submits that this feature has a non-obvious effect on the production of a semi-solid material having a desired microstructure.

For at least the forgoing reasons, the Applicant submits that independent claim 10 is clearly distinguishable over the '406 and '694 applications and any of the other art of record, whether considered along or in combination. Accordingly, withdrawal of the rejection of independent claim 10 is respectfully requested.

Independent Claim 50

Independent claim 50 is directed to a method of semi-solid forming a shaped article and recites, in pertinent part, the steps of regulating the transfer of an amount of the metallic melt into the temperature-controlled vessel, crystallizing the metallic melt by cooling the metallic melt at a controlled rate less than 0.5 degrees Celsius per second to produce a semi-solid material, and feeding the semi-solid material from the temperature-controlled vessel directly into the mold.

As discussed above with regard to dependent claim 25, this embodiment of the claimed invention is illustrated in Figure 9 of the subject application. However, the Applicant submits that neither the '406 application or the '694 application discloses that a temperature-

controlled vessel is used to produce a semi-solid material having a desired microstructure <u>and feeding the semi-solid material from the temperature-controlled vessel directly into a mold</u>. As discussed above, Figures 3 and 13 in the '406 application clearly illustrate the vessel 30 as being separate and distinct from the injection sleeve 50, 180. Similarly, Figures 3, 29, etc. in the '694 application illustrate the vessel 30 as being clearly separate and distinct from the injection sleeve 40, 70. Indeed, nowhere in the '406 application or the '694 application is taught or even suggested that the functions associated with the vessel 30 (e.g., receiving and controlling the cooling rate of the liquid alloy) and the injection sleeve 40, 50, 70, 180 (e.g., injecting the semisolid material into a mold to form a part) are incorporated into the <u>same structure</u> such that the semi-solid material may be injected <u>directly</u> into a die mold. Instead, with regard to the both the '406 application and the '694 application, the semisolid material must be transferred from the vessel into the injection sleeve, and then from the injection sleeve into the mold.

As should be appreciated, the added process step required by each of the '406 and '694 applications takes additional time to complete, thereby significantly increasing processing time. Additionally, the added step of discharging the semisolid material from the vessel into the injection sleeve increases the likelihood of contamination of the semisolid material, and may also effect the temperature of the semisolid material prior to injection into the mold, which may in turn have a negative effect on material microstructure. However, the method recited in independent claim 50 does not require the intermediate step of transferring material from a forming vessel to an injection sleeve. To the contrary, the temperature-

controlled vessel serves as both the container for forming the semi-solid material and also performs the function of feeding the semi-solid material directly into a mold. These functions are clearly performed by <u>separate structures</u> in the '406 and '694 applications.

For at least the forgoing reasons, the Applicant submits that independent claim 50 is clearly distinguishable over the '406 and '694 applications and any of the other art of record, whether considered along or in combination. Accordingly, withdrawal of the rejection of independent claim 50 is respectfully requested.

<u>Dependent Claims 51-57 and 77-84</u>

In addition to the reasons supporting the patentability of independent base claim 50, further reasons support the patentability of the claims depending therefrom. For example, dependent claim 54 recites the step of controlling the rate of displacement of the ram between about 1 inch per second and about 10 inches per second to provide non-turbulent flow of the semi-solid material into the mold. However, the '406 application discloses that the injection rate of the semisolid material is 0.5 meters/second, which is equivalent to 19.7 inches/second. Accordingly, the injection rate disclosed in the '406 application is considerably higher than the displacement rate range recited in dependent claim 54.

Dependent claim 80 recites the step of transferring the metallic melt into the vessel at a selected vessel temperature that is approximately equal to the temperature of the metallic melt. As discussed above with regard to dependent claim 8, the feature of controlling the temperature of the vessel prior to introduction of the molten metal therein is neither taught nor suggested by the '406 application nor the '694 application. Specifically, the '406 and '694

applications fail to disclose that the temperature of the vessel 30 is selected or controlled in an manner whatsoever prior to the transfer of liquid metal into the vessel 30. (See e.g., Figures 3 and 13 in the '406 application and Figures 3 and 29 in the '694 application). Moreover, there is certainly no indication or suggestion that the vessel temperature prior to introduction of liquid alloy is anywhere near the temperature of the metallic melt, as recited in dependent claim 80. As discussed above, the temperature range of 606 to 610 degrees Celsius referred to in paragraph 2, line 8 of the Office Action is the temperature of the metal introduced into the vessel, and does not in any way refer to a selected temperature of the vessel prior to introduction of the metal therein. Accordingly, the Applicant submits that dependent claim 80 is clearly distinguishable over both the '406 and '694 applications.

Additionally, dependent claim 81 recites the step of transferring the metallic melt into the vessel at a selected transfer temperature and at a selected transfer rate, and controlling a differential between the temperature of the metallic melt during the heating and the temperature of the metallic melt during the transferring. As discussed above with regard to claim 16, while the '406 and '694 applications appear to disclose a preferred heating temperature range of the molten metal and a preferred temperature range of the molten metal prior to being charged into the vessel, there is no indication or suggestion regarding providing control over the temperature differential between the molten metal during the heating and transferring steps.

Dependent claim 83 recites the additional steps of holding the metallic melt in an intermediate vessel prior to the transferring and controllably adjusting the temperature of the

metallic melt in the intermediate vessel prior to the transferring. As discussed above, even assuming arguendo that the ladle 10 could be considered an intermediate vessel and that the vessel 30 is a forming vessel for producing semi-solid material, there is no indication or even a suggestion that the temperature of the liquid metal contained within the ladle 10 is "controllably adjusted" to a selected transfer temperature prior to being transferring into the vessel wherein semi-solid material is produced. Instead, the temperature of the molten metal within the ladle 10 is subjected to uncontrolled ambient cooling.

Dependent claim 84 recites that the vessel includes a plurality of heat transfer zones, and independently controlling the temperature of the metallic melt disposed within the vessel adjacent each of the heat transfer zones. As discussed above, the vessels disclosed in the '406 and '694 applications do not include a plurality of heat transfer zones that serve to independently controlling the temperature of the metallic melt adjacent thereto.

Independent claim 66

Independent claim 66 is directed to a method of producing a semi-solid material without stirring and includes the steps of heating a metal alloy to form a metallic melt, preheating a vessel to a selected vessel temperature, and regulating the transfer of a select amount of the metallic melt into the vessel. The regulating comprises transferring the metallic melt into the vessel at a selected transfer temperature and at a selected transfer rate, and controlling a differential between the temperature of the metallic melt during the heating and the temperature of the metallic melt during the transferring. The method also comprises crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate to

form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix.

As discussed above, neither the '406 application or the '694 application disclose that the vessel 30 is in any way preheated to a selected vessel temperature prior to the introduction of metallic melt therein. Additionally, as discussed above with regard to dependent claim 16, while the '406 and '694 applications appear to disclose a preferred heating temperature range of the molten metal and a preferred temperature range of the molten metal prior to being charged into the vessel, there is no indication or suggestion regarding providing control over the temperature differential between the molten metal during the heating stage and the transferring stage. Additionally, the Applicant has amended independent claim 66 to recite that crystallizing the metallic melt is accomplished without the use of a grain refiner and without mechanical agitation. As discussed above with regard to independent claim 1, the '406 and '694 applications disclose processes that require at least one of these recited features.

For at least the forgoing reasons, the Applicant submits that independent claim 66, as now amended, is clearly distinguishable over the '406 and '694 applications and any of the other art of record, whether considered along or in combination. Accordingly, withdrawal of the rejection of independent claim 66 is respectfully requested.

Dependent Claims 67-75

In addition to the reasons supporting the patentability of independent base claim 66, further reasons support the patentability of the claims depending therefrom. For example,

dependent claim 70 recites that the selected vessel temperature is approximately equal to the temperature of the metallic melt. As discussed above, the '406 and '694 applications fail to disclose that the temperature of the vessel 30 is controlled in any manner whatsoever prior to transferring of liquid metal into the vessel 30, much less pre-heated to a temperature anywhere near the temperature of the metallic melt.

Additionally, dependent claim 71 further recites the steps of holding the metallic melt in an intermediate vessel prior to the transferring and controllably adjusting the temperature of the metallic melt in the intermediate vessel to the selected transfer temperature. As discussed above, even assuming arguendo that the ladle 10 illustrated and disclosed in the '406 and '694 applications could be considered an intermediate vessel and that the vessel 30 is a forming vessel for producing semi-solid material, there is no indication or suggestion that the temperature of the liquid metal contained within the ladle 10 is "controllably adjusted" to a selected transfer temperature prior to being transferring into the vessel wherein semi-solid material is produced.

CONCLUSION

Attached hereto are three (3) pages that present a marked up version of the changes made to this application by the current amendment. The first page of the three (3) attached pages is captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE".

In view of the foregoing amendments and remarks, it is respectfully submitted that Applicant's application is now in condition for allowance with now pending claims 1, 5-20,

24-26, 50-57 and 66-74 and 76-84. Reconsideration of the present application, as amended, is respectfully requested. Timely action towards a Notice of Allowability is hereby solicited. The Examiner is encouraged to contact the undersigned by telephone to resolve any outstanding matters concerning the present application.

Respectfully submitted,

By: ____________________

Brad A. Schepers
Reg. No. 45,431
Woodard, Emhardt, Naughton,
Moriarty & McNett
Bank One Center/Tower
111 Monument Circle, Suite 3700
Indianapolis, Indiana 46204-5137
(317) 634-3456

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claims 2-4 and 21-23 and 75 have been cancelled without prejudice for possible inclusion in a continuing application.

Claims 1, 8, 10, 24, 50 and 66 have been amended as follows:

1. (Twice Amended) A method of producing a semi-solid material without stirring, comprising:

heating a metal alloy to form a metallic melt;

regulating the transfer of an amount of the metallic melt into a temperature-controlled vessel; and

crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate less than 0.5 degrees Celsius per second <u>without the use of a grain refiner and without mechanical agitation</u> to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix <u>and having an average diameter no greater than about 50 μm</u>.

8. (Amended) The method of claim [5] <u>1</u>, wherein the regulating further includes transferring the metallic melt into the vessel at a selected vessel temperature.

10. (Amended) A method of producing a semi-solid material without stirring, comprising:

heating a metal alloy to form a metallic melt;

transferring a portion of the metallic melt into a holding vessel;

controllably adjusting the temperature of the metallic melt in the holding vessel to a selected transfer temperature;

regulating the transfer of an amount of the metallic melt from the holding vessel into a temperature-controlled forming vessel; and

crystallizing the metallic melt in the forming vessel by cooling the metallic melt at a controlled rate to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix.

24. (Amended) The method of claim 1, wherein the <u>temperature-controlled</u> vessel is a shot sleeve of a semi-solid forming press.

50. (Twice Amended) A method of semi-solid forming a shaped article, comprising:

providing a metal alloy, a temperature-controlled vessel and a mold;

heating the metal alloy to form a metallic melt;

regulating the transfer of an amount of the metallic melt into the <u>temperature-controlled</u> vessel; and

crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate less than 0.5 degrees Celsius per second to produce a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix;

feeding the semi-solid material from the temperature-controlled vessel directly into the mold; and

forming the semi-solid material into a shaped article.

66. (Amended) A method of producing a semi-solid material without stirring, comprising:

heating a metal alloy to form a metallic melt;

preheating a temperature-controlled vessel to a selected vessel temperature;

regulating the transfer of a select amount of the metallic melt into the vessel, the regulating comprising:

transferring the metallic melt into the vessel at a selected transfer temperature and at a selected transfer rate; and

controlling a differential between the temperature of the metallic melt during the heating and the temperature of the metallic melt during the transferring; and

crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate without the use of a grain refiner and without mechanical agitation to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix.